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SUPPLEMENTARY STUDIES ON THE DIFFERENTIAL MORTALITY WITH RESPECT TO SEED WEIGHT IN THE GERMINATION OF GARDEN BEANS

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I. INTRODUCTORY REMARKS

IN an earlier paper[1] I have shown that in field cultures the mortality of seeds of *Phaseolus vulgaris* is not random, but selective with respect to seed weight.

From the available data it appeared that both the upper and lower weight classes are more heavily drawn upon in the mortality than is the modal region of the seed weight distribution. So delicately balanced is this mortality of the two extremes in the particular series of experiments that the mean weight of the survivors in the long run differs not at all from that of the population from which they are drawn, while their variability, either absolute as measured by the standard deviation or relative as expressed by the coefficient of variation, is distinctly less than that of the original population.

Now while these results are deduced from such large and representative series of data, that their general validity for the specified conditions seems beyond much question, their substantiation has appeared to me for two reasons most desirable:

(*a*) The demonstration of selective elimination was somewhat indirect. Comparisons could not be made between the physical constants of the seeds which developed and those of all exposed to risk, or between the constants of those which actually failed and those which actually developed, but were necessarily drawn between the constants of the general population from which the seeds were taken for planting and those of the seeds which developed to maturity. The method is perfectly legitimate, providing the samples planted be drawn in a purely random manner (as they were in these experiments), but the probable error of random sampling is a two-fold one, and this increases the difficulty of determining the statistical significance of a given constant.

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[1] Harris, J. Arthur, "On Differential Mortality with Respect to Seed Weight Occurring in Field Cultures of *Phaseolus vulgaris*," AMER. NAT., 46: 512–525, 1912.

(*b*) The result seemed, *a priori,* improbable. Other studies[2] had demonstrated a moderately low but consistently positive correlation between the weight of the seed planted and the number of pods on the plant produced. It seemed reasonable to assume that since the larger seed produce the heaviest plants they are in general more vigorous, and hence should be more viable.[3] If the seeds increase in vigor and viability from the smallest to the largest, one would anticipate an increase in the mean of the survivors and a decrease in their variability resulting from the mortality in the lower part of the range of variation instead of a reduction in variability without a change in type (mean). These were the biological hypotheses which led me to question the generality of the statistical findings. Further work was therefore undertaken along various lines. Additional field cultures in which it will be possible to compare the constants of the seeds developing with those of the seeds failing, were made.[4] Such cultures can only substantiate, refute or modify the conclusions drawn from the experiments already carried out, but will not advance our knowledge of the proximate causes of the differential mortality. To this end, physiological (including chemical and physical) studies must be instituted.

The purpose of this paper is to discuss the results of one of these physiological experiments, in as far as they bear upon the questions of the existence of a differential mortality and of its consequences in the population. The evidence which they afford concerning the causes underlying the differential death rate is a question too complicated both biologically and statistically to be discussed in the limits of this paper.

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[2] Harris, J. Arthur, "On the Relationship between the Weight of the Seed Planted and the Characters of the Plant Produced," *Biometrika,* 9, pt. 1, 1913; also "The Size of the Seed Planted and the Fertility of the Plant Produced," *Amer. Breed. Mag.,* 3: 293–295, 1912.

[3] Providing of course that the correlation between size of seed planted and size of plant produced is not merely the result of extra reserve food in the larger seeds.

[4] The results of these and of other data from experiments made long since, but as yet in a raw condition, should be ready in a few months.

For a fair understanding of the portions of the data which are placed before the reader, it will be necessary, however, to state briefly the general purposes which led to the adoption of the particular methods employed.

On the assumptions that the vigor of the seeds increases from the lower to the higher weight classes,[5] one might expect a mortality of seeds in the lower portion of the range of variation due to innate incapacity for development. One must then seek some other factor to account for the mortality of the heavier seeds.

One of the simplest *a priori* assumptions is that the larger seeds require longer to germinate and that they are in consequence longer exposed to the vicissitudes of germination—to death by excessive moisture or by excessive draught before or shortly after expanding their leaves.

Now nothing whatever is here stated or implied in favor of any of these suggestions. For the present, they stand purely and simply as the first of a series of hypotheses to be tested in the quest of the true interpretation of an observed phenomenon. They are mentioned here solely to explain why a particular series of experiments was set up in the way in which it was.

II. METHODS

The first thing needful in testing these hypotheses is to determine the relationship between the size of the seed and the time required for its germination. To do this, while at the same time securing data for a further test of the existence of a selective mortality, one must work with as large numbers of seeds as possible in order to obtain a reliable measure of selective mortality as well as decisive constants for the relationship between seed weight and time required for germination, if it be of the low or moderate order that one might expect. It is desirable that the germination tests be made under conditions as uniform as possible. The technique adopted must also be practical—that is, in the case of the present study, the work was necessarily done at a season of the year when it would not interfere with other experiments; the seeds had to be germinated so that each of the many hundreds or thousands of pots could be examined without too great back or eye strain every three hours throughout the twenty-four during the whole period of germination; finally, the expense of setting up and maintaining the experiment had to be kept within reasonable limits.

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[5] The chief evidence in support of this view is that afforded by the results already mentioned for the correlation between the weight of the seed planted and the characters of the plant produced. But of course this correlation may be due solely to stored food materials.

These requirements seemed, after careful consideration, best met by planting the seeds separately in three-inch pots of moderately fine sand. To facilitate handling, the pots were filled with slightly moist sand which was generally allowed to dry before the seeds were planted. The whole experiment was then watered at the same time. In a few instances, it was impossible to have the sand of all the pots perfectly dry when the seeds were planted, but I believe this introduces only a small source of error, for in these cases the planting was rushed through as rapidly as possible, and the individually labeled seeds were always thoroughly shuffled before planting to counteract, in as far as might be, the heterogeneity of environmental conditions afforded by different parts of the greenhouse. The space on the benches was filled to the level of the top of the pots with sand to prevent too great evaporation.[6] The labels were completely sunk in the sand so that the series number and the weight of the seed were quite unknown at the time of recording the results. Thus personal equation as far as it implies any bias with regard to the material was absolutely excluded.

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[6] In a few earlier experiments, fine bench gravel was used, in the later ones, sand of the same kind as that in the pots. The gravel was employed at first, since I thought it might be feasible to water indirectly by flooding the gravel and allowing the sand to absorb it through the sides of the pots. This proved entirely impracticable. Not only was the method of watering unsuccessful, but the gravel permitted an enormous amount of evaporation.

At the outset, I must emphasize the fact that this technique (which I still believe is the best possible under all the requirements) falls far short of what one would desire. The germination of bean seeds under glass on a large scale is a rather difficult process. If a sufficient supply of moisture can be held in the soil from the beginning to the end of the experiment and the temperature be kept fairly high, the problem of good germinations in the greenhouse is solved. But when one is doing the work during the period of hot days and cool nights coming in the early fall, the question of maintaining proper soil moisture and temperature is a very serious one. It is remarkable how heterogeneous the environment of a single section of a greenhouse system is! This is especially noticeable in the drying out of the pots in sand cultures. Just here lies one of the greatest difficulties. The germinating bean seedling is very sensitive to watering, especially in connection with low temperature. I imagine this is particularly true of old seeds which have nearly lost their viability. Probably the considerable irregularity in our percentages of germination is very largely due to the impossibility of controlling closely enough the soil moisture.[7]

In classifying, three groups were recognized: (*A*) seeds germinating normally, (*B*) seeds germinating but producing seedlings more or less abnormal, (*C*) seeds failing to germinate.

On general grounds, the recognition of the three classes seemed desirable; for purposes other than those of this paper, it was essential. They can, of course, be combined

[7] The effect of this inability to control moisture sufficiently was, when present, always in the direction of a reduction of the percentage of germination through the rotting of some of the seeds, for in all cases the amount of water was finally sufficient to bring about germination.

at pleasure for comparisons. The distinction between *A* and *C* or *B* and *C* allows of practically no difference of opinion. Personal equation probably plays considerable part in distributing the seedlings between those which germinated normally and those which were somewhat abnormal, for there is no clear line of distinction between the two. Practically all the cases were decided by myself. The abnormalities were in small part teratological and in part physiological or pathological—*i. e.,* curved hypocotyls failing to bring the plumule promptly to the surface, cotyledons failing to free themselves from the seed coat, blighted primordial leaves, etc. The results of this study seem to indicate the need of more precise consideration of aberrant seedling in future experiments.

III. Materials

This research and the one which preceded it are in-between seed weight and seed mortality in *Phaseolus vulgaris* as a whole,[8] and at the same time lay up data which when sufficiently supplemented by others of various kinds shall enable one to determine whether (and if so, why) the relationship between seed weight and seed mortality differs from variety to variety, or whether it is dependent upon the conditions under which the seeds planted were grown or those under which they were germinated, or upon the age of the seeds.

Five characteristics were, therefore, deemed desirable in the seeds used. (*a*) They should be known from breeding tests to belong to strains as uniform as possible. (*b*) They should represent several distinct varieties. (*c*) Different lots should have been grown under as diverse environmental conditions as possible. (*d*) Different ages of as nearly as possible comparable seed should be investigated. (*e*) Comparison with the results of field experiments should be easily carried out.

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[8] The materials are, however, for technical reasons limited to the dwarf varieties.

These conditions were most satisfactorily met in the seeds held over from various pedigree experiments made during the last several years. Coupled with the favorable points of these are some obvious disadvantages,[9] which practically are of relatively small weight in view of the fact that it would require several years work to secure a better series.

It is unnecessary to devote space to the description of these materials, since the key letters used are those employed in previous papers, in which a large amount of quantitative information concerning them may be obtained.

Altogether thirteen "experiments" were made. That is, a greenhouse or a section of a greenhouse was filled thirteen times. These experiments are numbered *A* to *M,* and the letters separated from the pedigree formulæ by dashes in the tables refer to them. As a glance at the tables will show, several different series of seeds often went into a single experiment—the capacity of the small greenhouse being about 3,000 and that of the large greenhouse about 8,000 pots. The specific details of these experiments seem at present irrelevant.

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[9] Chief among these is the age of some of the seeds—resulting in very low percentages of germination. This is possibly a very important factor. The field cultures were grown in 1908, 1909 and 1910. The sand cultures, made in large part from samples of the same lots of seeds as used in the various field experiments, were carried out in the summer of 1912. Any one who takes the ratio of the seeds germinating to those actually planted for the individual samples will be impressed by the very low percentages of germination in these experiments. This is largely attributable to differences in age of seed, but in addition it will be noted that the seeds were grown under different environmental conditions and that they were germinated under conditions which could not be maintained the same from experiment to experiment. Inability to control temperature and substratum moisture may account for considerable differences.

Now it is clear that in these experiments it has not been possible to differentiate between the deaths which occurred in the seed envelopes and those which have taken place under the vicissitudes of field or sand culture conditions. This problem can not be profitably discussed until experiments under varying and carefully controlled conditions can be made with seed identical except for age. For such experiments one should start with large quantities of pedigreed seed and follow it through its period of viability. Material was bred for this purpose in the summer of 1912.

IV. ANALYSIS OF DATA

The distributions of seed weight are shown in the conventional units of .025 gram range.[10] Tables I–II give those for the seeds germinating normally, Tables III–IV for those which germinated but produced more or less abnormal seedlings,[11] Tables V–VI those for seeds which failed to germinate.

From these the three more essential physical constants (mean, standard deviation and coefficient of variation) have been deduced and are presented with their probable errors in Tables VII, VIII and IX.[12]

TABLE I

WEIGHT OF SEEDS GERMINATING NORMALLY

Series	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Totals
NHD–J......	—	2	4	8	14	18	12	9	3	6	—	1	—	—	77
NHD–M......	—	2	3	14	23	58	37	25	5	2	1	—	—	—	170
NHH–J......	1	—	—	7	29	38	71	27	16	13	6	—	—	1	209
NHH–M.....	—	—	5	30	88	158	186	120	50	19	11	6	3	—	676
NHHH–J.....	—	7	33	120	215	252	122	45	16	5	—	—	1	1	817
NHHH–M....	2	12	47	176	389	456	218	88	25	5	1	—	—	—	1,419
NHDD–J.....	—	1	8	42	140	233	225	142	51	17	8	—	—	—	867
NHDD–M....	1	5	20	59	202	344	318	175	58	16	5	6	—	—	1,209
NDH–D......	—	—	4	7	48	56	43	16	2	—	—	—	—	—	176
NDH–E......	—	1	1	31	65	87	54	16	3	—	—	—	—	—	258
NDD–D......	—	3	2	10	21	19	16	13	3	1	—	—	—	—	88
NDD–E......	—	—	4	5	16	17	12	3	—	—	—	—	—	—	57
NDDD–D.....	—	1	8	62	108	122	60	22	4	—	—	—	—	—	387
NDDD–E.....	—	—	6	67	106	98	53	35	7	—	2	1	—	—	375
NDHH–D....	1	7	17	66	144	153	98	25	2	1	—	—	—	—	514
NDHH–E....	—	4	10	50	122	154	81	24	6	—	—	—	—	—	451
FSS–I........	5	56	202	268	121	34	14	—	—	—	—	—	—	—	700
FSS–L.......	2	63	328	467	252	59	9	—	—	—	—	—	—	—	1,180
FSH–C.......	—	—	8	51	183	164	52	11	3	—	—	—	—	—	472
FSD–C.......	—	7	43	104	52	19	7	—	—	—	—	—	—	—	232
FSHH–C.....	4	34	178	317	223	89	20	2	—	—	—	—	—	—	867
FSDD–C.....	1	27	107	259	175	89	20	2	—	—	—	—	—	—	680

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[10] Class 1 = 0.000–0.025 gram, class 2 = 0.025–0.050 gram, etc. Thus to pass from the constants (means or standard deviations) in units to those in grams subtract .5 and multiply by .025.

[11] In some of these series, *N* is insignificant, but it has seemed best to lay the whole data before the reader. The degree of trustworthiness of the constants is indicated by their probable errors. In some cases, too, lots of material are combined.

[12] Tables of constants for $(A+B)$ and $(B+C)$ are not given, although they enter into some of the comparisons. They can be derived from the original tables of data or calculated from the constants for A, B and C by appropriate formulæ.

TABLE II

Weight of Seeds Germinating Normally

Series	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	Totals
USS–I . . .	—	1	1	1	13	39	106	142	162	176	135	120	78	47	18	21	9	4	3	3	3	1	1	—	—	1	—	—	—	—	—	1,085
USS–K. . .	—	—	—	2	5	16	41	90	141	167	206	181	107	88	37	10	3	3	—	—	—	—	—	1	—	—	—	—	—	—	—	1,098
GGH–F. . .	—	1	—	—	—	—	—	2	6	17	27	51	81	94	86	78	57	39	27	18	7	2	1	—	—	—	—	—	—	—	—	594
GGH–G. . .	—	—	—	—	—	—	—	—	—	3	10	16	33	32	32	23	17	14	4	2	3	—	1	—	—	1	—	—	—	—	—	191
GGH–K . .	—	—	—	—	—	1	—	2	6	13	20	41	57	60	60	61	54	29	14	10	4	1	1	1	—	—	—	—	—	—	—	435
GGH$_2$*–F* . .	—	—	—	—	—	1	1	3	1	8	22	29	76	77	58	55	45	26	10	8	5	—	—	—	—	—	—	—	—	—	—	425
GGH$_2$*–G* . .	—	—	—	—	—	—	2	5	2	4	19	20	41	38	41	23	16	19	7	7	3	1	—	—	—	—	—	—	—	—	—	248
GGH$_2$*–K*. .	—	—	—	—	—	—	—	2	7	6	12	27	30	51	50	44	54	29	15	6	4	1	3	—	—	—	—	—	—	—	—	341
GGD–F. . .	—	—	—	—	1	4	5	12	34	34	41	39	20	13	9	6	2	—	—	1	1	—	—	—	—	—	—	—	—	—	—	222
GGD–G. . .	—	—	—	—	2	3	2	13	11	27	17	22	5	5	9	2	1	—	1	1	—	—	—	—	—	—	—	—	—	—	—	121
GGD–K. . .	—	—	—	1	1	4	9	18	47	41	32	31	21	13	8	6	4	1	—	—	—	—	—	—	—	—	—	—	—	—	—	237
GGD$_2$*–F* . .	—	—	—	1	1	1	2	12	19	42	70	77	64	44	29	16	12	8	3	—	—	—	—	—	—	—	—	—	—	—	—	401
GGD$_2$*–G* . .	—	—	—	—	—	1	2	11	22	23	58	43	61	33	25	9	11	1	2	—	—	—	—	—	—	—	—	—	—	—	—	302
GGD$_2$*–K*. .	—	—	—	—	2	2	2	11	25	34	47	68	54	55	54	25	21	5	6	1	1	—	—	—	—	—	—	—	—	—	—	413
GGHH–F .	—	—	—	—	—	—	—	1	5	8	14	38	48	56	41	28	18	22	20	2	—	1	1	—	—	—	—	—	—	—	—	303
GGHH–G .	—	—	—	—	—	—	—	1	1	5	7	8	18	28	15	12	9	6	4	1	1	—	—	—	—	—	—	—	—	—	—	116
GGHH–K.	—	—	—	—	—	—	—	1	5	9	16	28	54	62	38	29	16	15	12	3	2	2	—	—	—	—	—	—	—	—	—	292
GGDD–F .	—	—	—	—	4	1	2	8	16	28	61	37	59	51	35	8	9	1	2	—	—	—	—	—	—	—	—	—	—	—	—	322
GGDD–G .	—	—	—	—	1	—	1	1	6	16	22	22	22	17	9	7	5	2	3	—	—	—	1	—	—	—	—	—	—	—	—	135
GGDD–K.	—	—	—	—	1	2	3	7	22	36	65	63	52	30	22	16	5	3	1	1	—	—	—	—	—	—	—	—	—	—	—	329
LL–A	—	—	—	—	6	6	5	3	8	10	18	8	4	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	69
LL–B	—	—	—	—	—	3	1	4	9	5	2	1	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	26
LLS–A. . .	—	—	4	11	13	25	33	51	37	48	37	43	24	13	9	10	4	1	—	1	1	—	—	—	—	—	—	—	—	—	—	365
LLS–B. . .	—	—	3	8	9	13	24	29	17	30	24	16	12	8	3	2	—	1	—	1	—	—	—	—	—	—	—	—	—	—	—	200
LLS–H. . .	1	3	10	34	75	165	207	272	299	303	259	204	153	87	51	40	26	13	2	3	—	—	—	—	—	—	—	—	—	—	—	2,207
LLS–K. . .	—	—	1	6	8	10	22	35	38	43	26	22	12	8	6	3	1	2	—	—	—	—	—	—	—	—	—	—	—	—	—	243
W–K.	—	—	—	—	—	1	2	7	14	20	39	42	57	60	56	61	55	34	33	19	13	10	11	6	3	2	2	1	—	—	1	549
GGS–L. . .	—	—	—	—	—	—	—	—	1	3	5	10	20	11	29	27	22	19	11	10	4	6	1	—	—	—	—	—	—	—	—	179

TABLE III

Weight of Seeds More or Less Abnormal in Germination

Series	4	5	6	7	8	9	10	11	12	13	14	15	Totals
NHD-J	—	1	4	6	9	14	12	4	—	3	—	—	53
NHD-M	—	1	—	5	18	24	26	11	3	1	—	—	89
NHH-J	—	—	—	1	13	13	16	11	4	—	—	—	58
NHH-M	—	—	—	1	17	42	39	26	14	6	1	2	148
NHHH-J	1	—	2	7	7	15	6	2	1	—	—	—	41
NHHH-M	1	1	2	7	10	17	8	7	—	—	—	—	53
NHDD-J	—	1	2	6	14	9	12	5	5	—	—	—	54
NHDD-M	—	—	—	4	12	24	10	3	2	2	—	—	57
NDH-D	—	—	—	10	32	28	30	11	—	—	1	—	112
NDH-E	—	—	1	17	27	40	26	10	4	1	—	—	126
NDD-D	2	1	2	4	9	19	8	6	—	—	—	—	51
NDD-E	—	—	1	3	10	9	10	2	3	—	—	—	38
NDDD-D	—	—	1	11	15	15	11	3	1	—	—	—	57
NDDD-E	—	—	2	8	9	4	5	1	—	1	—	—	30
NDHH-D	1	—	3	6	22	14	11	4	1	—	—	—	62
NDHH-E	—	—	1	6	6	14	12	1	1	—	—	—	41
FSS-I	1	7	24	28	6	1	—	—	—	—	—	—	67
FSS-L	—	8	30	33	24	11	4	—	—	—	—	—	110
FSH-C	—	—	—	12	39	39	24	10	2	—	—	—	126
FSD-C	—	5	10	28	12	1	—	—	—	—	—	—	56
FSHH-C	—	5	8	21	12	6	—	—	—	—	—	—	52
FSDD-C	1	2	7	20	13	3	1	—	—	—	—	—	47

Any conclusion concerning selective mortality must rest upon a comparison of these constants.

The method of making these tests demands a word of explanation. In the previous study, the comparison was necessarily drawn between the constants of the seeds which actually produced fertile plants and those of the general population from which they were drawn; the constant for the general population was subtracted from that of the sub-sample. The positive or the negative sign of the difference showed whether mortality had tended to raise or to lower mean or variability.

In these greenhouse experiments, on the other hand, we have the constants for samples (*A*) normally germinating, (*B*) germinating abnormally and (*C*) failing to germinate. (*B*) may possibly be regarded as intermediate between (*A*) and (*C*).

If we take the difference between the constants

Survivors *less* failed

we shall have plus differences of the mean if selection has tended to raise the general average by eliminating the

TABLE IV

Weight of Seeds More or Less Abnormal in Germination

Series	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	Totals
USS–I	—	—	—	—	7	4	7	9	9	4	2	5	2	—	2	—	—	—	1	1	—	—	—	—	—	—	—	53
USS–K	—	1	1	—	3	2	10	8	15	16	17	7	10	4	—	—	—	—	—	—	—	—	—	—	—	—	—	94
GGH–F	—	—	—	—	—	—	1	2	1	2	7	14	26	30	16	19	13	8	2	2	—	—	—	—	—	—	—	143
GGH–G	—	—	—	—	—	—	1	1	—	3	4	4	11	13	6	9	5	1	3	1	1	—	—	—	—	—	—	63
GGH–K	—	—	—	—	—	—	2	1	1	2	5	9	14	15	6	14	10	4	3	2	1	—	—	—	—	—	—	89
GGH_2–*F*	—	—	—	—	—	—	—	—	—	—	1	2	3	4	3	4	1	5	1	1	—	—	—	—	—	—	—	25
GGH_2–*G*	—	—	—	—	—	—	—	—	—	—	3	2	3	3	6	2	1	—	2	1	1	—	—	—	—	—	—	24
GGH_2–*K*	—	—	—	—	—	—	—	1	—	1	—	—	1	—	1	—	2	—	—	—	—	—	—	—	—	—	—	6
GGD–F	—	—	—	—	1	9	13	16	30	29	9	5	7	1	1	—	1	—	—	—	—	—	—	—	—	—	—	122
GGD–G	—	1	—	—	1	1	9	15	13	23	15	8	9	2	2	1	—	—	—	—	—	—	—	—	—	—	—	100
GGD–K	—	—	—	—	3	4	23	41	54	44	27	15	9	4	4	—	—	—	—	—	—	—	—	—	—	—	—	228
GGD_2–*F*	—	—	—	—	1	1	2	3	2	3	6	6	3	—	1	—	—	—	—	—	—	—	—	—	—	—	—	28
GGD_2–*G*	—	—	1	1	—	—	—	3	2	3	1	6	4	3	1	2	—	1	—	—	—	—	—	—	—	—	—	28
GGD_2–*K*	—	—	—	—	—	—	—	2	2	1	4	5	2	1	2	—	1	—	—	—	—	—	—	—	—	—	—	20
GGHH–F	—	—	—	—	—	—	—	1	1	—	1	2	1	7	1	1	1	3	—	—	—	—	—	—	—	—	—	19
GGHH–G	—	—	—	—	—	—	—	—	—	—	2	1	3	1	1	1	2	—	—	—	1	—	—	—	—	—	—	12
GGHH–K	—	—	—	—	—	—	—	—	2	1	1	—	—	1	1	1	1	—	—	—	1	—	—	—	—	—	—	9
GGDD–F	—	—	—	—	—	—	1	2	1	—	—	1	4	1	1	—	—	—	—	—	—	—	—	—	—	—	—	11
GGDD–G	—	—	—	—	—	—	—	—	1	—	2	2	2	1	—	—	—	—	—	—	—	—	—	—	—	—	—	8
GGDD–K	—	—	—	—	2	—	1	—	1	—	2	3	1	1	—	—	1	—	—	—	—	—	—	—	—	—	—	12
LL–A	—	—	—	—	1	2	4	8	11	8	14	2	6	3	—	—	—	—	—	—	—	—	—	—	—	—	—	59
LL–B	—	—	—	—	1	2	2	10	4	4	6	3	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	33
LLS–A	—	1	—	1	3	4	4	8	10	14	6	15	13	19	13	5	7	4	2	2	—	—	—	—	—	—	—	131
LLS–B	—	—	—	2	—	2	1	6	4	9	6	2	4	9	4	2	2	2	—	—	—	—	—	—	—	—	—	55
LLS–H	4	2	7	13	12	34	44	47	73	77	80	119	109	101	49	40	34	20	12	2	6	1	—	—	—	—	—	886
LLS–K	—	1	1	3	3	5	10	6	16	10	16	20	18	13	12	7	3	3	—	—	—	—	—	—	—	—	—	147
W–K	—	—	—	—	—	—	1	1	3	3	6	3	1	3	9	6	3	4	4	7	2	—	1	—	2	—	1	60
GGS–L	—	—	—	—	—	1	—	2	4	1	16	21	22	42	38	36	34	17	10	2	2	2	—	1	—	—	—	251

TABLE V

WEIGHT OF SEEDS FAILING TO GERMINATE

Series	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Totals
NHD–J	—	15	75	180	370	338	205	90	22	6	1	1	—	—	—	1,303
NHD–M	—	10	82	213	397	442	277	92	33	5	—	—	—	—	—	1,551
NHH–J	—	—	7	26	157	329	359	222	97	31	11	4	—	—	1	1,244
NHH–M	—	3	6	36	157	384	463	289	108	33	12	5	3	1	—	1,500
NHHH–J	2	7	23	82	164	201	95	31	15	3	1	—	—	—	—	624
NHHH–M	1	6	16	30	50	62	35	14	3	1	—	—	—	—	—	218
NHDD–J	—	2	10	33	92	116	112	69	24	7	2	—	—	—	—	467
NHDD–M	—	1	9	21	55	65	32	17	4	2	1	—	—	—	—	207
NDH–D	1	1	17	67	141	145	102	1	13	2	—	—	—	—	—	490
NDH–E	—	3	16	75	196	214	123	55	11	1	—	—	—	—	—	694
NDD–D	2	6	24	95	162	137	75	20	10	—	—	—	—	—	—	531
NDD–E	1	3	32	84	147	137	75	27	5	—	—	—	—	—	—	511
NDDD–D	—	2	8	33	64	65	51	15	5	1	—	—	—	—	—	244
NDDD–E	—	3	8	35	73	60	31	16	—	1	1	—	—	—	—	228
NDHH–D	—	1	13	53	101	91	52	23	2	—	—	—	—	—	—	337
NDHH–E	—	1	10	23	73	74	39	21	—	—	—	—	—	—	—	241
FSS–I	13	164	254	264	92	21	3	2	—	—	—	—	—	—	—	813
FSS–L	13	104	298	243	143	50	11	1	—	—	—	—	—	—	—	863
FSH–C	—	1	6	57	139	144	52	13	4	1	—	—	—	—	—	417
FSD–C	4	44	164	197	91	27	3	—	1	—	—	—	—	—	—	531
FSHH–C	1	12	62	114	93	31	10	3	—	—	—	—	—	—	—	326
FSDD–C	—	24	92	113	72	20	7	2	1	—	—	—	—	—	—	331

smaller seeds; we shall have negative differences for standard deviations and coefficients of variation if there is a mortality of both the larger and smaller seeds—thus increasing the variability in the eliminated sample and decreasing variability in the surviving population.

Hence, regarding the abnormal germinations (tentatively) as intermediate between normal development and failure, we take our differences:

(*A*)–(*C*), or normally germinating *less* failed,
(*B*)–(*C*), or abnormal *less* failed,
(*A*)–(*B*), or normally germinating *less* abnormal.

Since the number of individual experiments is fairly large, the comparisons may be made by merely noting the sign of the differences—*i. e.*, by taking the gross results of the individual experiments. Or one may treat the data from a more numerical view-point, taking averages of the actual differences. Both methods will of course be used.

In considering the differences between the constants of the three classes of seeds dealt with for the whole experi-

TABLE VI

Weight of Seeds Failing to Germinate

Series	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	Totals
USS–I	—	—	2	3	6	18	25	46	73	69	53	54	51	16	15	9	4	3	—	1	—	—	—	—	—	—	448
USS–K	—	—	—	2	3	3	9	27	20	40	47	50	30	20	9	6	3	1	1	—	—	—	—	—	—	—	271
GGH–F	—	—	—	—	—	—	1	4	2	4	10	17	15	31	34	31	29	20	29	8	5	—	2	—	—	1	243
GGH–G	—	—	—	—	—	—	—	4	3	9	11	18	25	44	40	42	29	25	9	7	3	3	4	—	2	—	278
GGH–K	—	—	—	—	—	—	—	2	2	3	7	13	16	30	31	36	25	12	5	7	4	1	1	1	1	—	197
GGH_2–*F*	—	—	—	—	—	1	—	—	1	—	4	7	12	6	8	6	8	5	1	2	1	—	—	—	—	—	62
GGH_2–*G*	—	—	—	—	—	—	1	3	—	—	4	9	3	13	21	12	10	5	2	—	2	—	—	—	—	—	85
GGH_2–*K*	—	—	—	—	—	—	—	1	—	2	—	5	2	10	13	8	8	4	2	1	1	—	—	—	1	—	58
GGD–F	—	—	—	2	2	—	5	4	16	16	13	16	7	1	—	1	—	—	1	—	—	—	—	—	—	—	84
GGD–G	—	—	—	2	2	6	13	21	24	28	27	21	20	14	5	2	1	2	—	—	—	—	—	—	—	—	188
GGD–K	—	—	—	1	—	5	7	12	26	38	37	23	22	7	6	2	1	—	—	—	—	—	—	—	—	—	187
GGE_2–*F*	—	—	—	1	—	—	3	1	5	4	9	7	14	3	3	—	—	—	—	—	—	—	—	—	—	—	50
GGD_2–*G*	1	—	1	2	5	1	2	9	6	7	5	18	25	15	9	1	4	4	—	—	—	1	—	—	—	—	116
GGD_2–*K*	—	—	—	—	—	—	2	5	2	7	6	13	7	8	6	3	3	—	1	—	—	—	—	—	—	—	63
GGHH–F	—	—	—	—	—	—	—	1	—	1	1	10	9	8	15	3	3	—	1	3	1	—	—	—	—	—	56
GGHH–G	—	—	—	—	—	—	—	—	—	—	5	3	8	5	6	7	2	3	2	3	1	—	—	—	—	—	45
GGHH–K	—	—	—	—	—	—	—	—	—	—	3	5	2	10	2	4	7	1	4	1	1	1	—	—	—	—	41
GGDD–F	—	—	—	1	—	—	2	2	2	3	3	10	—	4	1	1	—	—	—	—	—	—	—	—	—	—	29
GGDD–G	—	—	—	—	1	—	1	1	2	8	9	8	12	2	3	3	1	1	—	—	—	—	—	—	—	—	52
GGDD–K	—	—	—	—	1	—	—	2	5	9	8	5	2	6	3	1	—	1	1	1	—	—	—	—	—	—	45
LL–A	—	—	2	6	9	14	30	29	51	66	65	42	30	24	18	5	4	1	—	—	—	—	—	—	—	—	396
LL–B	—	—	—	—	7	16	41	55	68	85	86	57	42	16	9	—	1	3	1	—	—	—	—	—	—	—	487
LLS–A	—	—	3	2	4	9	9	9	8	10	8	9	9	7	8	5	1	1	—	—	1	1	1	—	—	—	105
LLS–B	—	—	3	9	9	16	28	24	36	26	37	23	24	25	23	16	11	10	4	2	—	1	—	—	—	—	327
LLS–H	—	—	3	15	18	24	15	34	34	46	43	43	49	56	61	44	38	21	13	12	5	4	—	3	—	—	581
LLS–K	—	—	—	3	1	3	3	4	3	3	2	3	3	7	7	9	2	3	1	—	1	—	—	—	—	—	58
W–K	—	—	—	—	—	1	1	3	5	6	9	3	6	5	14	7	9	8	5	8	4	—	2	—	2	—	98
GGS–L	—	—	—	—	—	—	1	1	6	6	5	28	41	64	86	92	86	66	53	25	15	19	9	2	3	1	609

TABLE VII

Physical Constants for Seeds Germinating Normally

Series	Mean and Probable Error	Standard Deviation and Probable Error	Coefficient of Variation and Probable Error
NHD-J	9.247 ± .154	2.006 ± .109	21.696 ± 1.233
NHD-M	9.276 ± .074	1.435 ± .053	15.464 ± .579
NHH-J	10.029 ± .078	1.678 ± .055	16.731 ± .567
NHH-M	9.889 ± .041	1.595 ± .029	16.132 ± .303
NHHH-J	8.649 ± .033	1.388 ± .023	16.049 ± .275
NHHH-M	8.686 ± .023	1.300 ± .017	14.792 ± .194
NHDD-J	9.597 ± .032	1.416 ± .023	14.753 ± .244
NHDD-M	9.465 ± .028	1.437 ± .020	15.187 ± .213
NDH-D	9.040 ± .057	1.123 ± .040	12.426 ± .454
NDH-E	8.849 ± .048	1.134 ± .034	12.812 ± .387
NDD-D	8.955 ± .116	1.618 ± .082	18.073 ± .948
NDD-E	8.649 ± .109	1.216 ± .077	14.055 ± .905
NDDD-D	8.628 ± .041	1.184 ± .029	13.719 ± .339
NDDD-E	8.739 ± .048	1.379 ± .034	15.781 ± .398
NDHH-D	8.607 ± .037	1.254 ± .026	14.565 ± .313
NDHH-E	8.732 ± .038	1.188 ± .027	13.610 ± .311
USS-I	14.215 ± .056	2.730 ± .040	19.208 ± .288
USS-K	14.911 ± .045	2.226 ± .032	14.930 ± .220
FSS-I	6.860 ± .027	1.057 ± .019	15.407 ± .284
FSS-L	6.947 ± .019	.950 ± .013	13.678 ± .193
FSH-C	8.521 ± .030	.959 ± .021	11.259 ± .250
FSD-C	7.232 ± .044	.996 ± .031	13.769 ± .439
FSHH-C	7.243 ± .025	1.083 ± .018	14.955 ± .248
FSDD-C	7.378 ± .028	1.094 ± .020	14.822 ± .277
GGH-F	18.841 ± .073	2.629 ± .052	13.953 ± .278
GGH-G	18.796 ± .119	2.446 ± .084	13.016 ± .457
GGH-K	18.790 ± .085	2.622 ± .060	13.956 ± .325
GGH_2-*F*	18.635 ± .078	2.396 ± .055	12.855 ± .302
GGH_2-*G*	18.440 ± .117	2.720 ± .082	14.749 ± .456
GGH_2-*K*	19.170 ± .096	2.633 ± .068	13.734 ± .361
GGD-F	15.140 ± .108	2.377 ± .076	15.699 ± .515
GGD-G	14.942 ± .160	2.601 ± .113	17.406 ± .864
GGD-K	14.776 ± .106	2.423 ± .075	16.398 ± .521
GGD_2-*F*	16.354 ± .079	2.347 ± .056	14.349 ± .349
GGD_2-*G*	16.275 ± .087	2.253 ± .062	13.844 ± .387
GGD_2-*K*	16.847 ± .086	2.593 ± .061	15.391 ± .370
GGHH-F	18.459 ± .097	2.511 ± .069	13.602 ± .380
GGHH-G	18.319 ± .149	2.381 ± .105	12.997 ± .585
GGHH-K	18.298 ± .096	2.439 ± .068	13.328 ± .379
GGDD-F	16.379 ± .087	2.311 ± .061	14.106 ± .382
GGDD-G	16.681 ± .150	2.588 ± .106	15.513 ± .652
GGDD-K	16.106 ± .083	2.243 ± .059	13.929 ± .373
LL-A	13.522 ± .193	2.380 ± .137	17.604 ± 1.042
LL-B	13.115 ± .247	1.866 ± .175	14.224 ± 1.357
LLS-A	13.759 ± .109	3.097 ± .077	22.511 ± .590
LLS-B	13.280 ± .140	2.943 ± .099	22.157 ± .783
LLS-H	13.772 ± .042	2.902 ± .030	21.068 ± .223
LLS-K	13.638 ± .116	2.671 ± .082	19.587 ± .622
W-K	19.329 ± .108	3.753 ± .076	19.417 ± .410
GGS-L	19.972 ± .141	2.799 ± .100	14.013 ± .509

TABLE VIII

PHYSICAL CONSTANTS FOR SEEDS MORE OR LESS ABNORMAL IN GERMINATION

Series	Mean and Probable Error	Standard Deviation and Probable Error	Coefficient of Variation and Probable Error
NHD-J	8.906 ± .159	1.714 ± .112	19.251 ± 1.307
NHD-M	9.325 ± .933	1.305 ± .660	13.993 ± .901
NHH-J	9.603 ± .109	1.229 ± .077	12.794 ± .814
NHH-M	10.047 ± .080	1.445 ± .057	14.387 ± .576
NHHH-J	8.537 ± .155	1.469 ± .109	17.209 ± 1.319
NHHH-M	8.679 ± .141	1.526 ± .200	17.578 ± 1.187
NHDD-J	9.019 ± .150	1.633 ± .106	18.107 ± 1.213
NHDD-M	9.175 ± .115	1.284 ± .811	13.933 ± .901
NDH-D	9.045 ± .076	1.198 ± .054	13.244 ± .607
NDH-E	8.984 ± .078	1.296 ± .055	14.429 ± .626
NDD-D	8.667 ± .151	1.601 ± .107	18.477 ± 1.275
NDD-E	9.105 ± .151	1.382 ± .107	15.180 ± 1.202
NDDD-D	8.649 ± .111	1.245 ± .079	14.395 ± .928
NDDD-E	8.333 ± .186	1.509 ± .131	18.111 ± 1.628
NDHH-D	8.444 ± .148	1.740 ± .105	20.609 ± 1.290
NDHH-E	8.902 ± .128	1.215 ± .091	13.647 ± 1.035
USS-I	14.019 ± .302	3.257 ± .213	23.236 ± 1.602
USS-K	14.766 ± .167	2.403 ± .118	16.275 ± .821
FSS-I	6.507 ± .071	.860 ± .050	13.219 ± .784
FSS-L	7.110 ± .076	1.184 ± .054	16.647 ± .778
FSH-C	8.896 ± .068	1.123 ± .048	12.628 ± .545
FSD-C	6.892 ± .077	.859 ± .055	12.468 ± .807
FSHH-C	7.115 ± .100	1.068 ± .071	15.004 ± 1.014
FSDD-C	7.170 ± .104	1.125 ± .074	14.792 ± 1.051
GGH-F	19.279 ± .130	2.310 ± .092	11.980 ± .485
GGH-G	19.238 ± .227	2.674 ± .161	13.899 ± .851
GGH-K	19.382 ± .197	2.759 ± .140	14.237 ± .734
GGH_2-F	20.400 ± .317	2.349 ± .224	11.514 ± 1.113
GGH_2-G	19.833 ± .375	2.721 ± .265	13.718 ± 1.360
GGH_2-K	18.333 ± .933	3.389 ± .660	18.485 ± 3.720
GGD-F	14.295 ± .123	2.007 ± .087	14.041 ± .618
GGD-G	14.950 ± .150	2.228 ± .106	14.903 ± .727
GGD-K	14.491 ± .085	1.896 ± .060	13.083 ± .420
GGD_2-F	15.321 ± .295	2.316 ± .209	15.114 ± 1.393
GGD_2-G	16.464 ± .422	3.311 ± .298	20.109 ± 1.884
GGD_2-K	16.750 ± .344	2.281 ± .243	13.619 ± 1.479
GGHH-F	18.947 ± .420	2.711 ± .297	14.308 ± 1.597
GGHH-G	19.417 ± .544	2.795 ± .385	14.396 ± 2.023
GGHH-K	18.556 ± .872	3.878 ± .617	20.897 ± 3.464
GGDD-F	16.363 ± .541	2.660 ± .383	16.259 ± 2.399
GGDD-G	16.875 ± .339	1.423 ± .240	8.435 ± 1.132
GGDD-K	15.667 ± .669	3.434 ± .473	21.921 ± 3.160
LL-A	14.932 ± .183	2.080 ± .129	13.927 ± .881
LL-B	14.152 ± .223	1.899 ± .158	13.420 ± 1.134
LLS-A	17.153 ± .209	3.550 ± .148	20.693 ± .898
LLS-B	16.473 ± .303	3.327 ± .214	20.194 ± 1.351
LLS-H	16.652 ± .080	3.538 ± .057	21.244 ± .355
LLS-K	16.244 ± .185	3.327 ± .131	20.482 ± .839
W-K	20.683 ± .384	4.410 ± .272	21.321 ± 1.371
GGS-L	19.900 ± .110	2.594 ± .078	13.038 ± .401

TABLE IX

Physical Constants for Seeds Failing to Germinate

Series	Mean and Probable Error	Standard Deviation and Probable Error	Coefficient of Variation and Probable Error
NHD–J	8.594 ± .026	1.413 ± .019	16.443 ± .223
NHD–M	8.659 ± .023	1.357 ± .016	15.675 ± .194
NHH–J	9.864 ± .027	1.397 ± .019	14.166 ± .195
NHH–M	9.905 ± .024	1.379 ± .017	13.917 ± .175
NHHH–J	8.654 ± .037	1.363 ± .026	15.752 ± .308
NHHH–M	8.491 ± .069	1.505 ± .049	17.723 ± .590
NHDD–J	9.351 ± .046	1.476 ± .033	15.781 ± .357
NHDD–M	8.821 ± .066	1.401 ± .046	15.878 ± .540
NDH–D	8.624 ± .038	1.239 ± .027	14.367 ± .316
NDH–E	8.804 ± .032	1.237 ± .022	14.050 ± .259
NDD–D	8.411 ± .038	1.314 ± .027	15.617 ± .331
NDD–E	8.444 ± .039	1.307 ± .028	15.484 ± .334
NDDD–D	8.746 ± .058	1.336 ± .041	15.275 ± .477
NDDD–E	8.531 ± .059	1.322 ± .042	15.499 ± .501
NDHH–D	8.564 ± .045	1.237 ± .032	14.444 ± .383
NDHH–E	8.701 ± .053	1.211 ± .384	13.917 ± .450
USS–I	14.435 ± .085	2.664 ± .060	18.451 ± .430
USS–K	15.092 ± .101	2.453 ± .071	16.251 ± .483
FSS–I	6.422 ± .025	1.066 ± .018	16.606 ± .285
FSS–L	6.693 ± .026	1.147 ± .019	17.134 ± .286
FSH–C	8.565 ± .035	1.073 ± .025	12.521 ± .297
FSD–C	6.779 ± .034	1.168 ± .024	17.235 ± .367
FSHH–C	7.331 ± .042	1.123 ± .030	15.317 ± .414
FSDD–C	7.018 ± .042	1.143 ± .030	16.284 ± .438
GGH–F	19.584 ± .129	2.979 ± .091	15.210 ± .476
GGH–G	19.194 ± .119	2.934 ± .084	15.285 ± .447
GGH–K	19.330 ± .131	2.729 ± .093	14.116 ± .489
GGH_2–F	18.597 ± .235	2.745 ± .116	14.761 ± .913
GGH_2–G	18.718 ± .184	2.583 ± .134	13.798 ± .727
GGH_2–K	19.328 ± .238	2.688 ± .168	13.906 ± .887
GGD–F	14.286 ± .172	2.334 ± .121	16.335 ± .872
GGD–G	14.500 ± .128	2.598 ± .090	17.920 ± .643
GGD–K	14.690 ± .106	2.141 ± .075	14.578 ± .519
GGD_2–F	15.400 ± .216	2.262 ± .153	14.688 ± 1.012
GGD_2–G	15.827 ± .218	3.483 ± .154	22.005 ± 1.020
GGD_2–K	16.302 ± .223	2.628 ± .158	16.122 ± .994
GGHH–F	18.321 ± .221	2.451 ± .156	13.378 ± .868
GGHH–G	18.978 ± .270	2.687 ± .191	14.157 ± 1.027
GGHH–K	19.341 ± .294	2.787 ± .208	14.412 ± 1.095
GGDD–F	15.103 ± .325	2.591 ± .229	17.154 ± 1.563
GGDD–G	16.019 ± .225	2.406 ± .159	15.020 ± 1.016
GGDD–K	15.822 ± .293	2.918 ± .208	18.442 ± 1.355
LL–A	14.356 ± .070	2.704 ± .050	18.832 ± .467
LL–B	14.154 ± .070	2.280 ± .049	16.106 ± .357
LLS–A	14.571 ± .266	4.036 ± .188	27.698 ± 1.384
LLS–B	15.036 ± .142	3.794 ± .100	25.233 ± .706
LLS–H	16.480 ± .117	4.169 ± .082	25.295 ± .531
LLS–K	16.362 ± .376	4.240 ± .266	25.914 ± 1.728
W–K	19.092 ± .282	4.140 ± .199	21.683 ± 1.093
GGS–L	20.350 ± .078	2.867 ± .055	14.088 ± .278

ment, it is necessary to note that, except for the coefficients of variation, these constants are in absolute values. Clearly enough a difference of .254 unit in mean or of .197 in S.D. for White Flageolet beans with an average weight of 6.755 units and a S.D. of 1.071 units is not comparable with a difference of the same absolute amount in Golden Wax or Burpee's Stringless with a mean weight of, say, 18.401 and a scatter in weight of 2.544 units.

TABLE X[13]

PHYSICAL CONSTANTS FOR GENERAL POPULATION

Series	*N*	Mean and Probable Error	Standard Deviation and Probable Error	Coefficient of Variation and Probable Error
NHD.....	6,630	8.529 ± .012	1.458 ± .009	17.099 ± .103
NHH.....	7,334	9.774 ± .011	1.421 ± .008	14.537 ± .082
NHHH...	5,601	8.609 ± .012	1.338 ± .009	15.543 ± .101
NHDD....	5,029	9.417 ± .014	1.484 ± .099	15.763 ± .109
NDH.....	3,227	8.852 ± .015	1.555 ± .011	14.089 ± .121
NDD.....	2,362	8.487 ± .019	1.377 ± .014	16.218 ± .163
NDDD....	1,946	8.649 ± .020	1.315 ± .014	15.210 ± .168
NDHH...	2,433	8.604 ± .017	1.252 ± .012	14.549 ± .144
USS......	3,271	14.640 ± .030	2.519 ± .021	17.205 ± .148
FSS......	3,740	6.755 ± .012	1.071 ± .008	15.854 ± .126
FSH......	2,122	8.516 ± .016	1.092 ± .011	12.826 ± .135
FSD......	1,989	6.956 ± .016	1.034 ± .011	14.858 ± .161
FSHH....	1,788	7.225 ± .017	1.080 ± .012	14.953 ± .172
FSDD....	1,643	7.213 ± .019	1.127 ± .013	15.623 ± .188
GGH......	2,828	18.919 ± .034	2.674 ± .024	14.131 ± .177
GGH_2.....	1,284	18.799 ± .049	2.608 ± .034	13.873 ± .188
GGD......	2,140	14.972 ± .036	2.498 ± .026	16.681 ± .193
GGD_2.....	1,419	16.379 ± .046	2.577 ± .033	15.732 ± .204
GGHH....	1,329	18.401 ± .047	2.544 ± .033	13.824 ± .184
GGDD....	1,093	16.298 ± .048	2.395 ± .044	14.700 ± .216
LL.......	1,070	14.206 ± .050	2.443 ± .036	17.197 ± .260
LLS......	5,305	14.826 ± .033	3.570 ± .023	24.077 ± .167
W........	707	19.412 ± .099	3.888 ± .070	20.032 ± .374
GGS......	1,039	20.176 ± .059	2.800 ± .041	13.876 ± .209

[13] These constants are, except for the *LL*, *LLS* and *GGS* series, calculated directly from the data tabled for the general populations. In the case of the *LL* series the seeds were already a selected class—the heavier and lighter having been drawn for the planting giving rise to *LLS* plants. Hence in this case the constants were based on the summed seriations for the seeds failing, producing abnormal seedlings and producing normal seedlings in the two lots. They will differ somewhat from those of the whole population of seeds weighed. In the *LLS* and *GGS* series the tables for the general population were not yet prepared, hence the seriations of the seeds of classes (*A*)–(*C*) were summed for the various experiments and served as the basis for the general population constant.

Hence these absolute differences must, for the sake of convenience and of strict comparability, be reduced to relative terms. The best way of doing this is to express them in percentages of the general population values for the same constant, where ''general population'' means the whole mass of the particular strain and series of seeds from which the seeds for the individual experiments were drawn.

In the discussion of the whole series of experiments both absolute and relative values will be taken into account. In the preparation of the diagrams for differences in mean and S.D. the relative (percentage) values only will be used.

Table X gives the physical constants for the general populations, and the numbers of seeds upon which they are based.

I now turn to the various comparisons. It would be desirable to place before the reader the individual differences and their probable errors, but since these number 750 their publication is precluded by lack of space, and the small summary tables must suffice. All these differences may, of course, be derived by the reader caring to check the arithmetic from the tables of fundamental constants.

(*To be concluded*)